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THE
LOGIC AND MAGIC OF
COLOR

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AN EXHIBITION CELEBRATING
THE CENTENNIAL ANNIVERSARY
OF THE COOPER UNION

THE
LOGIC AND MAGIC OF
COLOR

20th April - 31st August, 1960
THE COOPER UNION MUSEUM
COOPER SQUARE, NEW YORK 3

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INTRODUCTION

Of all visual phenomena, color is so common a part of our lives that few of us ever really see it and fewer still speculate on such simple yet enigmatic questions as how and when colors were named as they are, whence come the dyes that color our clothes and the pigments we spread across a canvas, how designers gauge the mercurial world of color fashion, to what degree colors better or worsen our psychological and even physical lives, or simplest and most puzzling of all: what, exactly, is color.

To the manufacturer and the shopper who buys his merchandise, color is one thing; to the artist concerned with the visual effect of pigments, it is another; and to the psychologist evaluating his experiments in reactions to color, it is something else again. Each, however, is dependent on the other for a full realization of a specific color, and no attempt at a true explanation of that color's creation can be made without considering color in all its aspects, a consideration that in the end must necessarily offer an answer to the question, what, exactly, is color.

The earliest and a most remarkable exploration into the problem is found in Aristotle's discussion of the five senses in which he says we cannot see color without the help of light. Light to Aristotle was an "activity," a force that when "excited to actuality" produced the sensation of color, providing a foundation for subsequent developments in the science of color. Further on, however, Aristotle gives an intricately metaphysical analysis of the senses, describing their interdependence and fundamental connection with the soul. Actual knowledge is quite different from potential knowledge, says Aristotle; a distinction nicely expressed in a statement in which he appears to turn from an observation of physical color itself to contemplate the eye, "that which sees," with a suggestion of the complexities involved in the brain's response to color: "If to perceive by sight is just to see, and what is seen is color (or the colored), then if we are to see that which sees, that which sees originally must be colored. It is clear therefore that 'to perceive by sight' has more than one meaning; for even when we are not seeing, it is by sight that we discriminate darkness from light, though not in the same way as we distinguish one color from another. Further, in a sense that which sees is colored; for in each case the sense-organ is capable of receiving the sensible object without its matter. That is why even when the sensible objects are gone the sensings and

imaginings continue to exist in the sense-organs.” (*De Anima*, Book III, chap. 2).

On such expositions as this is built the whole body of the metaphysical phenomenology of color, ranging from the latest psychological data based on carefully annotated experiments, to the wildest sort of fantastic beliefs, rooted in cabalism and peasant mythology. Objective science, on the other hand, is responsible for the creation of the dyes and pigments that form the bulk of familiar color matter, while the physiological perception of color involves the eye, whose reliability as a judge — though this fact is often ignored — is so completely relative that the exact measurement of color is only possible through scientifically complex machinery.

Questions about color inevitably reach into almost every branch of science, into philosophy, philology and the arts, as well as the intuitive practices of business — questions demanding a balance of “actual” and “potential” knowledge, of abstruse argument and empirically tested fact for answers that are not always visually demonstrable.

COLOR AND LIGHT

Color springs, literally, from the aether, for in the view of physical science it is correct to assign color not to an object but rather to the light reflected from the object. The sweater we wear is only red or blue or gray when we deal with it in practical, household terms; as an example of scientific explanation, its color is a sensation received as an image on the retina of the eye. In this scientific perception of color, the color-producing sensation is always caused by light which is but one of several aspects of radiant energy.

Invisible to the human eye are those forms of radiant energy known as radio waves, infra-red and ultra-violet radiation, X-ray and gamma rays, while light that can be seen is contained within the visible spectrum, composed of a distinct series of colors ranging from violet at one end to red on the other. We see the spectrum in exactly this range created naturally when there is a rainbow or, more commonly, a layer of oil slick on a wet pavement. Our knowledge of the spectrum as a scientific phenomenon stems chiefly from the late 17th century when Sir Isaac Newton recreated the colors of the spectrum by directing light through a prism. Newton was aware that not all colors were of precisely the same nature; the difference in their appearances to the eye had to be accounted for in terms of physical science and Newton concluded that “it is manifest that if the Sun’s Light consisted of but

one sort of Rays there would be but one Colour in the whole World, nor would it be possible to produce any new Colour by Reflexions and Refractions, and by consequence that the variety of Colours depends upon the composition of Light."

We know today, substantiating Newton's conclusion, that every color has a particular "Ray" all its own, what in modern terminology is called a wave-length. The wave-lengths of light visible to the eye are measured in millimicrons (one millimicron, abbreviated $m\mu$, is twenty-five millionths of an inch) with the range from violet to red confined to wave-lengths between 380 and 760 millimicrons. When all wave-lengths within these measurements are presented to the eye in approximately equal quantities we have a sensation of colorless, or "white" light. The phenomenon of the rainbow, caused by sunlight dispersed on the curved surfaces of raindrops, and the beam of white light passed through a prism are examples of the separation of white light into its component wave-lengths. On the other hand, white light may be created by overlapping red, green and blue light, a demonstration illustrating additive color mixture since it is the addition of each of the three colors to the other two that in effect produces the white light, and, consequently these are called the additive primaries (No. 7). A second set of primary colors, red, yellow and blue, are related to subtractive color mixture, since each color subtracts its complementary from white light (No. 9). Technically, the subtractive primaries are not red, yellow and blue but magenta, yellow and cyan. The magenta absorbs green, the yellow absorbs blue, and the cyan absorbs red, resulting in black since all light has been subtracted.

Most ordinary objects absorb differing amounts of light of differing wave-lengths and our perception of a particular color is a result of the sensation produced by the light that is not absorbed but reflected. The red book-cover has a coloring material whose physical structure is such that it absorbs all light but that wave-length which produces red. Another aspect in the distribution of wave-lengths is scattering. The color of the blue sky is affected by the relative scattering of sunlight by the atmosphere. Variations in the density of the atmospheric gases scatter the shorter wave-lengths at the blue end of the spectrum more than they scatter the longer wave-lengths. When the sun is high in the sky, enough short wave-lengths are present to make the sky appear blue, but early or late in the day, the sun's rays strike the earth more obliquely, passing a much greater distance through the atmosphere and causing the longer wave-lengths to be more apparent, with a consequent change in

color from blue to yellow, orange and red, the usual colors of the evening sky.

When a painter paints with oils or watercolors, a dyer colors his cloth or a lighting technician uses color filters, each modifies a white or colored surface in such a way that it takes on further color. Usually this is achieved through the use of pigments or dyes whose color relies on the principle of subtractive mixture, and this is why to most of us "red, yellow and blue" are the primary colors.

In addition to refraction, in which we see the spectrum produced by light through a prism (No. 1), the spectrum is seen in other phenomena such as interference, where a light ray reflected from the bottom surface of a film such as that found in a soap bubble or the oil slick on wet pavement travels a slightly greater distance than a parallel ray reflected from the top surface. Some wave-lengths are weakened more than others as the crests of one wave penetrate the troughs of another, causing the interference. The spectrum is again seen when white light is separated by diffraction, achieved, for example, through the use of evenly ruled surfaces, called diffraction gratings, with the rulings sometimes so close together they are invisible to the eye yet effectively diffract the white light (Nos. 6, 11). In the former, the molecules of a fluorescent material absorb radiant energy of one wave-length and re-radiate it as another wave-length; the radiant energy thus absorbed frequently comes from outside the visible spectrum, as in the instance of "black light." Stage costumes that glow in the dark under ultra-violet radiation from lamps with filters that absorb the visible radiation and re-radiate ultra-violet radiation are dyed in such a way that the invisible ultra-violet radiation is returned from the costume itself as a visible color. Even more intricate is polarization, in which light is said to be polarized or non-polarized depending on the relation of reflected light to refracted light (Nos. 14, 17); as a visible phenomenon, it may be observed in material with a pronounced lustre or sheen.

With our perception of color dependent on the behavior of wave-lengths and their phenomenal peculiarities, it is not surprising to find these peculiarities amply represented in nature as well as in the physics laboratory. The iridescence in mother-of-pearl (No. 42) and in the plumage of certain birds (Nos. 130, 124) and insects (No. 125) is the result of interference and diffraction, while the spectacular effect of cut crystal (No. 2) — and of diamonds — is due to prismatic refraction.

Among the many artists whose chief concern has been color, the group known

as the Orphists deliberately set out to represent on canvas their interpretations of the phenomena observed when white light was separated into its spectral colors (No. 185). At its height about 1912, Orphism was an important movement in the early history of non-figurative painting and at the same time extended the artist's use of color beyond an interest in surface effects to the deeper confines of symbolism and its psychological relations to music.

The point of view expressed in a physical analysis of color, that color and light are one and the same thing, that color is light, serves as a solid base that is by no means the entire explanation of the production and interpretation of color, yet in an infinite number of ways, color's production and interpretation are next to meaningless without an understanding of this physical genesis of color.

NATURE AND COLOR CHEMISTRY

Color is a child not only of light, but of the material characteristics of whatever it is the light falls upon. The red sweater, as a phenomenon of physics, is red because all wave-lengths but one are absorbed, yet the wave-length must be "excited to actuality" in some way, and, in fact, the sweater's redness is dependent on the dyeing of its fibres. The molecular structure of the particular substance in which it is dyed in a sense predetermines what wave-lengths shall and shall not be absorbed and reflected, a scientific process confined to chemistry.

The ancient Egyptians were among the world's first and most accomplished color chemists, using the earth's natural resources (No. 43) for a marvelous variety of coloring materials to dye their clothes and their hair, and paint their bodies. Dioscorides, Theophrastus and Vitruvius all have things to say about dyes and dyeing methods in Greco-Roman times, but the richest literary source of the ancient world is Pliny's *Natural History* in which he tells not only from what animals and plants particular dyes were made but, even more valuable historically, recipes for such famous dyes as indigo and the elusive purple made from the murex shells found along the Mediterranean shores of Europe, Africa and Asia Minor.

Purple, in its rarity, became the prerogative of kings; they were crowned in robes of purple, and buried in sarcophagi of porphyry, the reddish-purple rock expensively mined in Egypt. Dyes and pigments were a major factor in the economic and political shifts of power that marked the transition of medieval Europe from a feudal to a commercial society. Wars were fought, new dye and pigment

sources found, and new compounds invented when in the middle of the 19th century the accidental discovery that dyes could be made wholly from coal tar compounds dissolved in a breath the whole system of natural dyes and pigments that had served the commercial world for centuries. Today, the creation of the immense variety of colors which surrounds our daily lives is so infinitely complex a process, dependent on a specialized knowledge of chemistry, that it is entirely outside the experience of the ordinary individual. It is inconceivable that a lady of today would produce her own face rouge, as did her 18th-century counterpart, by boiling a mixture of Brazil Wood shavings and Roch Alum in red wine "Till two-thirds of the liquor are consumed. When this decoction has stood till cold, rub a little on the cheeks with a bit of cotton." Even dyeing methods were understood by the average man in an earlier age and, to some extent, probably used in the home. An early 19th-century magazine, Ackermann's *Repository*, gives instructions for "Domestic Processes for Dyeing Woolen, Silk, Cotton, and other Stuffs, a Permanent Yellow, Red, Crimson, Blue, Brown, Buff, Nankeen, Fawn Colour etc., etc." Wool could be dyed brown or fawn by "making a decoction of the green covering of the walnut. It is well known that walnut-peels strongly dye the skin. To dye brown with them, nothing else is required than to immerse the article in a warm decoction of them till it has acquired the wished-for colour."

Not all recipes were quite so simple, many having several more steps including the addition of subtle amounts of such chemicals as "crystallized acetate of copper" and "sal ammoniac" at the right moment. The heart of these recipes, whether for the home manufacture of cosmetics or small factory production of dyes, lies in the use of particular natural substances as the foundation for all coloring matter, and while these substances frequently underwent considerable chemical action before they were ready for actual use as a dye or pigment, the result is termed "natural" since the ultimate source was some material found in nature, a term readily understood when we know that modern dyes and pigments not only finish but begin as purely synthetic substances.

Alchemy, in the popular imagination, is associated with quackery and occult mysteries but alchemy is also the respectable parent of chemistry. The practice of alchemy, known to the early Greeks and probably to the Egyptians, was initially concerned with the transmutation of base metals into gold and, although its ethics became increasingly tarnished during the Middle Ages, alchemy developed many

of the technical methods and much of the apparatus of present-day chemistry. Coupled with alchemy's naive belief in the philosopher's stone was a very practical discovery which, at a very early date, influenced the chemical creation of color. Alchemists noticed that on dipping hot metals into their various mordant baths they acquired unusual colors, or became "dyed." Eventually, the colorers of metals and dyers of fabrics were in an identical business, and today we speak not only of "dyeing" fabrics but the term is also used for the process by which anodized metals are colored (No. 91).

The colors of our clothing, wallpaper, automobiles, the covers of the books we read, of everything in which color is not the direct result of natural creation, are the product of either dyes or pigments. Distinctions between the two lie chiefly in the nature of the substance; dyes are organic and soluble while pigments, with certain exceptions, are inorganic and insoluble. Prior to the mid-19th century, both relied on an assortment of animal, mineral and vegetable sources with the same source frequently capable of producing either a dye or pigment. The earliest dyes were probably discovered by accident and may have been stains from berries, fruits and nuts used as food. Dyeing as an art seems to have independently developed and been practiced among primitive peoples everywhere (Nos. 133, 156). From simple origins, dyeing quickly became a relatively complex chemical procedure often requiring several days of boiling, filtering and oxidization. Most dyes relied on the action of mordants to make them "fast," or firmly adherent, with the customary mordant a soluble salt of aluminum, iron or tin.

Among the great names in natural dyes were madder, kermes, and cochineal (No. 49) for red, weld for yellow, murex for purple (No. 61), and woad and indigo for blue (Nos. 57, 58). Nearly all dye sources were plants or animals and at an early point in the history of dyeing it was realized that plant dyes adhere most successfully to plant fibres and animal dyes to animal fibres. Minerals, on the other hand, were almost exclusively raw materials for pigments (Nos. 43, 44).

While many pigment sources, such as malachite and lapis lazuli, are familiar through frequent use in their natural state (No. 119), others are generally unrecognizable. These are what medieval writers classified as "artificial" pigments, manufactured salts such as vermilion, a compound of mercury and sulphur, or verdigris, produced by treating copper plates with the acetic acid vapors given off by vinegar. By modern standards, the manufacture of both dyes and pigments in the past must

have known its share of incalculable risks as the quality of natural substances was certain to vary and formulas were often loosely inexact, risks which since the development of synthetic dyes and pigments are, by comparison, reduced to near non-existence.

Synthetic dyes owe their immediate origin to William Henry Perkin, who as a young medical student in London attempting to prepare quinine synthetically discovered that his result was not the desired medicine but a blueish-red dyestuff obtained from the distillation products of coal tar. Perkin's first aniline dye was a violet-colored mauveine, "Perkin's mauve," and its commercial manufacture began in 1857, only a year after its discovery (No. 74). Soon, an aniline red was developed, later called fuchsine or magenta (No. 76), then further experiments saw the conversion of fuchsine into violet, blue and green derivatives. Dyestuff chemists worked empirically with little real knowledge of the chemical structure of the molecules involved and why they behaved as they did. In 1869, Friedrich Kekulé published a formula which held that a hexagonal ring structure may be assigned to benzene, and from C_6H_6 , six parts carbon and six parts hydrogen, is derived the molecular constitution of benzene. Kekulé's theory became the foundation of benzene chemistry and of all subsequent dyestuff research (No. 81).

Synthesized alizarin and azo dyes were born in 1868 and 1877, and one of the greatest triumphs of dyestuff chemistry was the later synthesis of indigo. Pigments, always closely related to dyes, were drawn even closer within the framework of organic chemistry and dyes and pigments together share the practical results of chemical compounds which solely through the molecular arrangement of elements produce the astonishing variety of colors that are manufactured today. Research, however, just as in the old days of the alchemists, is a never-ending quest, and as the past hundred years have witnessed extraordinary developments in the physical creation of color, present-day science invents not only new colors but new materials, materials offering new challenges to color chemistry.

VISUAL PHENOMENA, SYSTEMS AND COLOR MEASUREMENT

Color, wave-lengths of light reflected from material objects, is seen by the human eye. With its complex physical apparatus, the eye forms an image of the color as a wave-length of light on the eye's retina, a lens that is the rear surface of the eyeball, immediately causing an electric disturbance which activates special light-

sensitive elements within the retina. Connected with the brain by the single optic nerve behind each eyeball, these elements are the rods and cones. How, precisely, rods and cones separate one color from another is unknown, and while physiologists do know that cones are responsible for color vision and rods for vision that merely distinguishes degrees of light and dark, they can only speculate on the exact nature of the physical process of color selection.

The phenomenon of color mixture indicates that the retina must respond in at least three different ways to different colors. Still the most widely accepted general explanation is that of Young and Helmholtz, who concluded there must be three distinct kinds of cone receptors, separately responsive to either red, blue or green wave-lengths. All other colors were conceived as blends of differing degrees and proportions on the part of these three, a mutual interaction accounting for non-primary colors, while color-blindness, according to the Young-Helmholtz theory, is caused by peculiar deficiencies in one or more of the three sets of cone receptors.

As mysterious as the physical function of cones in the eye's retina are various psychophysical optical phenomena such as after-images, contrast-enhancement and fusion. There are many kinds of after-images, with the usual chromatic phenomenon termed a complementary after-image in which visual concentration on red, for example, will cause an after-image of green the brief second the eye looks away from the stimulating color (No. 23). A more readily observable phenomenon involving complementary colors is contrast-enhancement. Red immediately juxtaposed with green, or blue with yellow, increases the intensity of each; a particular red appears "redder" and the green "greener" than when seen independently. Fusion is an optical mixture of two colors in which the eye sees neither as it is in isolation but an apparent third color created by juxtaposed complementaries.

Visual phenomena were long ago empirically understood by artists and craftsmen. The knowing use of red-green contrast-enhancement by Delacroix is certainly matched for brilliant effect, for instance, in specific 15th-century Spanish textiles (No. 19) while both Alberti and Filarete, important figures of the Renaissance in 15th-century Italy, wrote that with red next to green, each enhanced the vividness of the other. The 19th century saw the formulation into rational principles of these empirical practices, and the culmination of "scientific" painting was reached with Seurat, who, relying on what he called "the simultaneous contrast of colors," related his pointillist technique to the theoretical ideas of Chevreul.

Chevreul, director of the Dye Works of the French Gobelins factory, set out to discover why there were complaints about the quality of certain colors prepared in the Gobelins' dyeing laboratories. His investigations (No. 40) led him to conclude that "the want of vigor" imputed to particular colors was "owing to the colors contiguous to them, and that the matter was involved in the phenomena of the contrast of colors." Chevreul wrote a monumental treatise based on his findings that not only influenced the course of impressionist and post-impressionist painting, but also acted as a spur to the century's increasing scientific concern with color. Typical of this concern is a criticism of Chevreul's method from a later work, *Field's Chromatography*: "Chevreul went entirely by the judgment of the eye. This method is open to much objection, as even the most carefully trained eyes are liable to be misled, and influenced by association." Out of this kind of critical approach have grown a number of intricately detailed color systems, with the two best-known and most frequently-used today called, after their founders, the Ostwald and the Munsell systems. Less generally familiar is the equally important, and somewhat more specialized, CIE (Commission Internationale d'Eclairage) system, which has developed the chromaticity diagram, a horseshoe-shaped map whose outer boundaries represent the pure spectrum colors in relation to each other (No. 200).

Both the Ostwald and Munsell systems rely for color gradations on three specific concepts: hue, value and chroma. Hue defines the color in relation to the spectrum, whether it is red, or green or orange and so on; value is the relative degree of light or dark, ranging from white to black; and chroma describes a particular color's intensity, whether it is a very dull or extremely brilliant color (Nos. 205, 206). Frequently, color scientists will substitute the terms brightness and saturation for value and chroma.

Users of either the Ostwald or Munsell system are apt to be partisan in their choice, with the pro-Ostwald faction likely to comprise those who work with color in a creative capacity, and the pro-Munsell group those concerned with the measurement and the exact matching of color. Each group finds that the distinctions which set one system apart from the other are its very virtues, distinctions that exist, however, within a general framework which at a casual glance would convey an impression of nearly duplicate systems.

The measurement of color, or colorimetry, is a demanding discipline vital to the

unknown millions who have ever tried to match a particular color with more of the same, as well as to all in the manufacturing world whose livelihood may depend on a color's constancy, to the maintainers of safety color codes (No. 211), and even to graders of commercially processed foods. Related to measurement is the identification of the elements of chemistry on the basis of color, with helium initially discovered through its identifying yellow color; and color is an integral and complex part of the Quantum Theory.

In the United States the National Bureau of Standards, assisted by the learned and professional associations composing the Inter-Society Color Council, has done much to establish carefully worked-out standards for measuring color, employing all the technical resources of modern science. Among the many mechanical devices employed for color measurement, the ultimate in exactness is the spectrophotometer, which can plot a graph that will include all the wave-lengths, with measurements of their relative strength, that are reflected by any hue submitted for analysis (No. 217).

Highly specialized colorimetry prefers letters and numbers to actual names for color designations. A dark green-yellow in the Munsell system, for example, may be described by GY 3/8, in which 3 specifies value and 8 chroma. This is a long way from the designations used in what is perhaps the earliest system for color standardization we know: heraldry. The familiar color terms in medieval heraldry, *or* for gold, *argent* for silver, *sable* for black, *gules* for red, and so forth, were closely connected with the overlapping symbolism of the period and may have stemmed from Aristotle's transposition of the names of the seven planets to metals and colors. In practice, however, the color terms in heraldry were apparently represented by conventional rendering; *argent* by unfilled space, *or* by dots, and vertical, horizontal or diagonal lines with combinations of the three for the remainder. Heraldic colors were, consequently, not only standardized in terminology but recognizable solely on the basis of a simple system of lines and dots, a system that while primitive in degree is not so far removed in kind from today's use of specific letters and numbers.

Standardization is equated with stability, a permanence which in its flexible accommodation of all the variations of value and chroma attached to a hue nevertheless establishes a fixed order of distinctions that is completely unaffected by the associative ideas inevitably related to color names. Names, however, are the garb

of fashion whose soul is change. *The Dictionary of Color* by Maerz and Paul lists over four thousand color names. Colors popular ten, twenty, a hundred years ago have been forgotten and we might believe that "nankeen," a great favorite in the 18th and early 19th centuries, is a color forever lost until we realize that only the name and not the color is gone. Fashion's constant search for uniqueness demands unique colors and such is the color "consumer's" psychological reaction that he will often accept as unique what is in actual fact a familiar color with a new name, a fiction compounded when individual manufacturers and professional employers of color formulate their own "unique" color ranges.

Turquoise, beige, persimmon, coral, lime are terms for which our imaginations have an instantaneous color image. Color names in all their inconstancy appeal to our apparently natural desire for variety, a pleasantly irrational state of mind that is frivolously mercurial and wholly opposed to the standardization of color terminology.

The eye, filtering and transmitting light waves to the brain which produces sensations of color, is physically incapable of the exacting measurement of color. Yet because of the peculiar interaction between the eye's physical function and psychological responses in the brain, any personal evaluation of color is a conceptual process whose sole "mechanical" tool is the eye. Optics and color measurement become the bridge between physics and metaphysics, the certain wave-length of light and the uncertain response in the human brain.

COLOR AND HUMAN RESPONSE

If, as in the instance of after-images, and the fusion of colors in the eye, man's physical apparatus is sometimes subject to tricks that are not entirely explainable, his powers of reason in matters of color are almost always at the mercy of the human psyche's arbitrary whims and irrational fancies. Hard as this may be to believe, we need look no farther for evidence than the accounts of a primitive homeopathy that relied on the magical use of color, or the intricacies of a color symbolism whose origins are frequently unknown yet which survives in so many uses today, or ask ourselves why it is we prefer this color to that and why we associate particular states of mind with particular colors.

The magical properties of color are even today, among less medically advanced peoples, a fixed part of cures for diseases. Frazer, in *The Golden Bough*, tells of an

elaborate ceremony once practiced in India for the cure of jaundice in which the yellow color was banished to yellow creatures and yellow things, such as birds and the sun, and to procure for the patient a healthy red color from a vigorous source, usually a red bull. A priest, reciting an appropriate Vedic hymn, performed a series of rites that relied on physical contact between the patient and the dead bull's blood, hair and skin. For cures, and especially as preventive protection, probably nothing in the magical world has ever surpassed gems (No. 270). The brilliance of cut and polished stones, often so different from their initial drab appearance, is in itself a magical achievement that borders on sorcery.

All ancient peoples seem to have worn quantities of gems and while it is true they may have often been worn simply as adornment, gems probably had a dual function with their role as amulets as significant as any other. A fine emerald insured its owner of a good memory, eloquent speech and even powers of prophecy; rubies preserved bodily and mental health, removed evil thoughts and dissipated pestilential vapors; jasper cured snake bites; and wearers of agate were guarded from all dangers, free of insomnia and sure to have pleasant dreams. In nearly all such uses is traceable a relationship between the good acquired or evil warded off and the color itself, an elementary symbolism that is a universal aspect of magic.

In an early 14-century manual for the faithful, *Mirror of Human Salvation*, the author warns us not to marvel that the same things may signify the devil at one time and Christ at another. In considering any connection between colors and particular emotions or as distinct symbols, we can never be inflexibly didactic. There is never exclusively one symbolic meaning attached to a color, for in every concrete situation, the color or colors involved are not only outer aspects, surfaces, but also expressions of the situation itself. These concrete situations are doubtless what the author of the *Mirror of Human Salvation* had in mind, and what the eminent, modern-day psychologist, Kouwer, means by the "polyvalence" of colors, the multiple potentialities in the meanings of color depending on concrete situations. Red does not stand only for anger or passion or blue for fidelity. Color symbolism cannot be reduced solely to a list of contrasts, sin and love, supreme joy and base desire, but to an infinitely subtler analysis in which colors and whatever meanings are associated with them are always subject to shifts in interpretation. It frequently becomes a question of the emotional weight attached to words themselves, a weight that differs in time and place and especially in language. In poetic

German, for example, “die Bäume grünen, der Himmel blaut,” are expressions meaning not that the trees become green and the sky turns blue but the trees *are* green and the sky *is* blue, representing a use of a color word as a verb, a physical activity in the best Aristotelian sense. Ruskin, commenting on the color perception of the Greeks, finds it all founded primarily on the degree of connection between color and light. Homer’s use of purple nearly always means “fiery, full of light,” and, says Ruskin, light subdued by blackness, according to Aristotle, becomes red; and blackness, heated or lighted, also becomes red. The perfect physical analogy for this metaphysical idea are the transitions from day to night and night to day, the red skies of dawn and dusk.

Black, white and red, a triangle in which red is always at the apex, served Goethe for his quasi-scientific color theories as well as they did the Greeks, and they are essential symbolic colors in innumerable primitive rites (No. 173). Red is the color “par excellence,” comments Kouwer. Its chromaticity has the maximum concentration; with red, reason is replaced by the irrationality of action and the dynamics of the moment. It is impossible to keep red at a distance or to rationalize it.

Red is a symbol of life in its animal, corporeal aspect, of fever as well as glowing health, of masculinity, aggressiveness, evil and sacrifice. It is the color of Bacchus in his role as god of regeneration. Red is almost always, in its ultimate symbolic derivation, associated with blood, shown not only by philological comparisons of word roots but by its extensive use as visual symbolism.

During the Middle Ages, that great era of symbolism, all colors were endowed with meaning and red assumed its secular place as the preserve of kings and princes and its religious significance for the Holy Blood (No. 262) and the Triumph of Christ at the Resurrection (No. 197) as well as the sacrifice of martyr saints, and the church adopted red as a canonical color for feasts commemorating sacrifice (No. 269).

For the Chinese, red is the color of joy and good fortune. In India it is a color for weddings (No. 268); and an ancient Hindu gem treatise asserts that to kings alone were allowed two varieties of colored diamonds, “those red as coral and those yellow as saffron.” The Indians of North and Central South America use black, white, red and yellow to distinguish the four points of the compass. Of all “chromatic” colors, those other than gradations of black and white, yellow

is the one most consistently allied with red, the two appearing as constant companions in Oriental symbolism (No. 273), and, in nearly all languages, are the first of the "chromatic" colors to acquire distinct names. This phenomenon is attributed to the relative conspicuousness of red and yellow as opposed to green and blue, the most commonly found colors in nature and, as a consequence, colors that recede in our conscious awareness. Goethe called blue "ein reizendes Nichts" (an alluring nothingness), and almost everywhere blue is the last of the primary colors to be indicated by a special term, with some peoples having no names at all for blue other than "like the sky."

Language is, however, an uncertain measure of the quality of color perception. The African pygmies of the Ituri forest in the Belgian Congo have no specific name for green, which is "like the leaves," and differing colors dark in value are all regarded as black, yet they make clear distinctions among particular shades of colors such as white and brown, distinctions that are not always apparent to our own differently conditioned eyes (No. 178). Terminologies may be simply a means for vocal expression of a much deeper color-perception process that involves several of the senses, a unity of function to a point where one is able to say "not that my senses but that I perceive," red or blue or green. This unity, or synesthesia, has no agreed-upon physical or even metaphysical explanation, yet it has been recognized as a phenomenon since at least the time of Aristotle, and the numerous attempts throughout history to create a color music have been one of its chief visible symbols. The symbolist poets felt the impress of synesthesia: Mallarmé speaks of "des yeux bleus et froids," and Rimbaud's sonnet, *The Vowels*, begins "A noir, E blanc, I rouge, O vert, U bleu." Involuntary reactions to color, like those of the factory workers who became easily excited and tired quickly when the factory's windows were covered with red, and who reacted conversely when the red was replaced by green, may also be a form of synesthesia.

In spite of psychological conditioning on the part of advertising, the "consumers" of color still have color preferences that are synesthetic in origin. Colors are "warm," "cold," "hard," and "soft," and as one person views a particular color as warm, another sees it as cold. Preference even extends to a point where one who favors warm colors will choose warm shades of such cool colors as green and blue, and another who favors cool colors will have a reverse preference. Individual color preferences are part of a larger, a mass preference and each feeds on the other.

Color choice is subject to influences that are entirely non-psychic in origin; imaginative theatrical costuming, the paucity of dyes and pigments in wartime, technical developments in creating new colors and developments in lighting techniques that affect the appearances of color, and even the arbitrary preference of a public personality. Geography and climate affect the color choice of whole groups of peoples. Strong, constant sunlight requires colors of strong intensity; any others are visually ineffective.

Through a mysterious interaction of all these forces, certain colors become fashion, a process so real that not only decades but centuries are often conceived in terms of particular colors. Within these arbitrarily defined units, fashion is never still, constantly shifting, but shifting in what appears as quite definite cycles (No. 286). "Kitchens and bathrooms were a porcelain and surgical white. Furniture was in natural wood tints, surfaced with colorless finish . . . things were, so to speak, as God made them — each object deriving its color from the material of which it was fashioned. . . . Turn now to the thoroughly painted home of 1928. . . . This quotation from *Fortune* of February, 1930, could easily have been written in 1960, and the "thoroughly painted home" not 1928 but 1958. A general color cycle has been repeated and will doubtless be repeated again.

While the directional movement of color cycles may correspond to the color order of the spectrum, there appears to be a very definite correlation of color fashions among clothing, interior decoration and, today, even automobiles, but it is difficult to say which sets the pace, how the influences are really transmitted, or whether each maintains a color cycle that is actually independent of its relatives, all questions in which psychology and its commercial periphery have indistinguishable roles.

As the data of psychology aim to lift scientific reason out of psyche's chaos, psychology must nevertheless always adjust, even submit to the forces of irrationality and become a part, with symbolism and language, of metaphysics. While the physics of color — color as light — and color chemistry — the creation of color through chemical means — are measurable, predictable, and to an extent controllable, the metaphysics of color, the complex reactions we have to color and why we have them, represent the final, and determining, stage in our perception of color.

CATALOGUE

COLOR AND LIGHT

Demonstrations in this section have been developed by Professor Milton Stecher of the Physics Department, Cooper Union School of Engineering, except where otherwise noted.

1. Demonstration of the prismatic refraction of light into its spectrum; lucite prism
2. Candelabrum; cut glass, ormolu, Wedgwood jasperware; England; about 1785; Cooper Union Museum
3. Natural calcite crystal showing color fringes due to air space at cleavage surface
4. Demonstration of *Newton's Rings*, spectral colors produced by interference phenomenon
5. Two optical flats showing the interference of light rays
6. Colored point light sources seen through two-dimensional diffraction grating provided by 200-mesh wire cloth
7. Additive mixture of light; overlapping beams of red, blue and green light produce white light in region of overlap
8. Demonstration of the disposition of phosphors on a color television screen; Radio Corporation of America
9. Subtractive mixture of light; filters of magenta, cyan and yellow produce black in region of overlap
10. Neon, argon and helium gases producing colored light alone and in interaction with phosphors and colored glass; Corning Glass Center
11. Sheet diffraction grating, 13,400 lines per inch, used for measurement of wavelengths in the visible spectrum; to be used to view the discrete and continuous spectrum of half-phosphored fluorescent tube
12. Half-phosphored fluorescent lamp; demonstrating the use of a coating of phosphors, which absorbs the radiant energy of the discrete wave-lengths in the spec-

trum of mercury vapor and remits this energy in a continuous spectrum which appears white

13. Spectrometer; measures the wave-length of light
14. Dark field kaleidoscope; made and lent by Professor Milton Stecher
15. Mechanical polaroid kaleidoscope; Sun Chemical Corporation
16. Kaleidoscope projection; Tom Lee, Ltd.
17. *Polarized Light Machine*; made by Hannes Beckmann; Cooper Union Art School

VISUAL PHENOMENA AND COLOR PERCEPTION

18. HRR, (Hardy-Rand-Rittler), color perception test; American Optical Company, Instrument Division
19. Textile fragment; silk compound satin; Spain, Mudejar; 15th century; Cooper Union Museum
20. Textile fragment; brocaded silk and metal compound cloth; Spain; 14th century; Cooper Union Museum
21. Series of five paintings, *Five Aspects of Scarlet*; oil on canvas; Ben Cunningham (1904-); United States; 1950; Ben Cunningham
22. Bookpaper, decorated paper for book-lining; Turkey; 20th century; Cooper Union Museum
23. Demonstration of after-image of complementary color; half-black, half-white disc with notch on periphery through which red light is seen when rotated one way, shows green when rotated in other direction; Physics Department, Cooper Union School of Engineering
24. Section of woman's blouse; appliqué and patchwork; cotton; Panama, San Blas Islands; 20th century; Cooper Union Museum
25. Painting, *The Scroll*; oil and wood strips on wood; Hannes Beckmann (1909-); United States, New York; 1956; Hannes Beckmann

26. Textile length, *Cutout*; printed cotton; designed by Alexander Girard; produced by Herman Miller, Inc.; United States, New York; 1956; Cooper Union Museum
27. Chart; additive and subtractive films; Cooper Union Art School
28. Chart; ten examples of volume color; Cooper Union Art School
29. Chart; eighteen-step grey scale; Cooper Union Art School
30. Chart; subtractive and additive films; Cooper Union Art School
31. Chart; volume color and temperature change; Cooper Union Art School
32. Chart; shadow on color, light on color; Cooper Union Art School
33. Chart; blue film over eight hues; Cooper Union Art School
34. Chart; hues, tints, shades, tones; Cooper Union Art School
35. Chart; demonstration of luminous color and additive color mixture; Cooper Union Art School
36. Progressive steps in the design of textile weaving; stones, leaves, pastel color rubbings, woven textile swatches; designed and lent by Helen Kroll Kramer
37. Painting, *Ultra-violet Hallucination*; oil on canvas; Ben Cunningham (1904-); United States, New York; 1959; Ben Cunningham
38. Studies in luminosity and vibration; Cooper Union Art School
39. Painting, *Modes of Appearance of Color — Surface, Film and Volume*; oil on canvas; Ben Cunningham (1904-); United States; 1951; Ben Cunningham
40. Book, *De la Loi du Contraste Simultané des Couleurs*; M. E. Chevreul; France, Paris; 1839; Dr. Sidney M. Edelstein
41. Book, *Chromographie ou l'Art de Composer un Dessin*; Rouget de Lisle; France, Paris; 1839; Dr. Sidney M. Edelstein
- NATURE AND COLOR CHEMISTRY
42. Group of shells; The American Museum of Natural History
43. Group of minerals; steatite, turquoise, lapis lazuli, azurite, malachite, cinnabar, carnotite, red clay, jasper, agate, sulphur, tourmaline, labradorite; The American Museum of Natural History
44. Ceramic jar containing cinnabar (ochre pigment); Mexico, Tlatilco; 800 B.C.; The American Museum of Natural History
45. Cosmetic jar containing kohl (antimony); serpentine; The Brooklyn Museum
46. Cosmetic jar containing kohl (antimony); anhydrite; Egypt; 12th dynasty (2000-1800 B.C.); The Brooklyn Museum
47. Cosmetic jar containing kohl (antimony); alabaster; Egypt; 18th dynasty (1500-1350 B.C.); The Brooklyn Museum
48. Cosmetics; eye shadows, lipsticks, mascara pencils, hair rinses, loose and compact powders; Helena Rubinstein
49. Raw cosmetic pigments; H. Kohnstamm & Company, Inc.
50. Slate palette with bits of green pigment adhering; Egypt, Mezaideh; pre-dynastic (3400-3200 B.C.); The Brooklyn Museum
51. Pigments; yellow and red ochre, light blue and cobalt frit; Egypt, Tell-el-Amarna (1355-1317 B.C.); The Brooklyn Museum
52. Scribe's palette with red and black pigments adhering; wood; Egypt, Thebes; New Kingdom (1300-1100 B.C.); The Brooklyn Museum
53. Jar; reduction-fired unglazed red clay; Egypt; pre-dynastic (4000-3500 B.C.); The Brooklyn Museum
54. *Bes* amulet; Egyptian paste; copper carbonate colorant; 20th century reconstruction of early Egyptian ceramic techniques by Anthony Giambalvo at The Brooklyn Museum Research Laboratory; The Brooklyn Museum
55. Fish bowl; porcelain with underglaze decoration; China; Ming dynasty (1368-1644); Cooper Union Museum
56. Book, *L'Art de L'Indigotier*, from the series, *Arts et Métiers*; M. de Beauvais

- Raseau; France, Paris; 1770; Dr. Sidney M. Edelstein
57. Textile, *Pheasant in Foliage*; cotton, indigo resist-printed; England or United States; late 18th century; Cooper Union Museum
 58. Textile border; linen, embroidered in indigo- and madder-dyed silk threads; Turkey, Bokhara; 18th or 19th century; Cooper Union Museum
 59. Playing cards; indigo and other inks on paper; Japan; 19th century; Jan Kindler
 60. Shells; *murex brandaris*; The American Museum of Natural History
 61. Textile fragment; linen with stripes of *Tyrian purple*, (murex-dyed,) wool; Middle East; Palmyra; 83 or 103 A.D.; William J. Young
 62. Bridal shirt; murex-dyed cotton; Mexico, Pacific coast of Middle America; 20th century; The American Museum of Natural History
 63. Murex-dyed yarn; Pacific coast of Middle America; 20th century; Junius B. Bird
 64. Photographs of Middle American Indians dyeing cloth with murex; The American Museum of Natural History
 65. Photograph of purple dye pits still showing traces of murex dye; Lebanon, Jubail (ancient Byblos); Arthur Damask
 66. Raw glazes and fired glaze samples; American Art Clay Company
 67. Plates showing underglaze cobalt; United States, Syracuse; Onandaga Pottery Company
 68. Vase; cobalt glaze; Adelaide Robineau (1865-1929); United States, Syracuse; second quarter 20th century; Everson Museum of Art
 69. Shallow bowl; stoneware, copper and cobalt glaze; United States; mid-20th century; Everson Museum of Art
 70. Beaker; earthenware, crazed copper glaze; Théodore Deck (1823-1891); France; late 19th century; Cooper Union Museum
 71. Covered urn; lavender blue and white jasperware; Josiah Wedgwood; England; late 18th century; Mr. and Mrs. Byron A. Born
 72. Mocha set; porcelain, cobalt glaze, silver and wood mounting; France; about 1925; Cooper Union Museum
 73. Wallpaper colonette; printed from wood blocks; France; about 1825; Cooper Union Museum
 74. Patent issued for William Henry Perkin's mauve; England; 1856; Dr. Samuel Zuckerman
 75. Textile fragment; brocaded silk taffeta dyed with fuchsine; France (?); 1870-1890; Cooper Union Museum
 76. Textile; silk compound cloth, dyed with fuchsine; France; late 19th century; Cooper Union Museum
 77. Sample book, *Simpson, Maule & Nicholson's Patent Aniline Dyes*, 1865; Dr. Sidney M. Edelstein
 78. Chair; baked enamel on metal, seat of cotton cloth; Eero Saarinen; United States, Pennsylvania; 1959; Knoll Associates
 79. Wallpaper pilaster and cornice. *Pêche*, from the series *La Chasse*; printed from wood blocks; Jules Desfossé; France, Paris; about 1860; Cooper Union Museum
 80. Textile, *Pythagoras*; printed linen; Sven Markelius; mid-20th century; Knoll Associates
 81. Sample pieces of pulp paper, wool, silk, leather and aluminum each dyed with alizarin blue GRL; Allied Chemical Corporation, National Aniline Division
 82. Molding powders of phenol-formaldehyde resin for the making of *Bakelite*; Union Carbide Plastics Company
 83. Dry pigments; Allied Chemical Corporation, National Aniline Division, Harmon Colors
 84. Vinyl coated cloth for automobile upholstery; Canadian Industries, Ltd., Fabrikoid Division
 85. Vinyl wall covering, *Vicartex*; embossed; L. E. Carpenter Company

86. Printed aluminum foil wrapping; Reynolds Metal Company
 87. Acetate yarns, Celaperm; *dope-dyed*; Celanese Corporation
 88. Viscose yarns; *dope-dyed*; American Viscose Corporation
 89. Automobile paint color samples; Allied Chemical Corporation, National Aniline Division, Harmon Colors
 90. Graded series of painted oil cans; Sears Roebuck and Company
 91. Color chips of anodized aluminum; Aluminum Company of America
 92. Three isomeric dye formulas, with examples of their dyeings on cotton; Allied Chemical Corporation, National Aniline Division
 93. Papers for packaging food stuffs, dyed with United States Government certified food colorants; Allied Chemical Corporation, National Aniline Division
 94. Cigar box labels, *None Better*, *Harry's*, *Bracelet* and *Aetna*; chromolithographs; United States; about 1880; Jan Kindler
 95. Progressive proofs of four-color printing; Horan Engraving Company, Inc.; United States, New York; 1949; Cooper Union Museum
 96. Wood block print, *Shono Rain*, from the series *The Fifty-Three Stations of the Tokaido Road*; Hiroshige (1797-1858); Japan; about 1834; Cooper Union Museum
 97. Progressive steps in wood block printing; Japan; 20th century; Cooper Union Museum
 98. Tear sheets of color mixtures for newspaper letterpress; Sun Chemical Corporation
 99. Transparent film printed in flexographic ink; Sun Chemical Corporation
 100. Vase; free-blown and panelled glass; United States; 1840-1860; The Corning Museum of Glass
 101. Goblet; opaque and clear free-blown glass; Salviati & Company; Italy, Venice; 1860-1880; Cooper Union Museum
 102. Culletts of colored glass; Corning Glass Center
 103. Panel of leaded stained and painted glass, *Annunciation*; France; 13th century; French & Company
 104. Demonstration of biological stains applied to various tissues for the purpose of exposing foreign material; Allied Chemical Corporation, National Aniline Division
- MEANING AND PLEASURE IN COLOR
105. Painting, *Mystères de la Mer*; oil on canvas; Odilon Redon (1840-1916); France, Paris; about 1910; The New Gallery
 106. Painting, *Man on Horseback*; watercolor on paper; Odilon Redon (1840-1916); France, Paris; about 1905; Mr. and Mrs. Eugene Thaw
 107. Toilet bottle; marbled glass; France; 17th century; Cooper Union Museum
 108. Bookpaper; marbled and combed; produced by La Maison de Beau Papier; France; about 1950; Cooper Union Museum
 109. Amulet, the deity *Bes*; faience; Egypt; late dynastic (500-300 B.C.); Mathias Komor
 110. Fragments; striped cane glass; Egypt; The Corning Museum of Glass
 111. Composite glass eye; Egypt; 1st millennium B.C.; The Brooklyn Museum
 112. Glass inlay, lower portion of a seated deity; Egypt; Ptolemaic (300-100 B.C.); The Brooklyn Museum
 113. Fragment of a glass vessel; cane glass; from the tomb of King Tuthomosis III (1490-1436 B.C.); Egypt; about 1450 B.C.; The Brooklyn Museum
 114. Cane glass inlay square, rosette decoration; Egypt; 1st century A.D.; The Brooklyn Museum
 115. Sistrum handle; faience; Egypt; Ptolemaic (4th to 3rd century B.C.); The Brooklyn Museum
 116. Figure, *Silenus* (?); faience; Egypt; late Ptolemaic or early Roman; The Brooklyn Museum

117. Rose in a glass; rhodonite, jade, rock, crystal, gold; Carl Fabergé (1846-1920); Russia, St. Petersburg; late 19th-early 20th century; A la Vieille Russie, Inc.
118. Vase; smoky topaz rock crystal, gold base; Carl Fabergé (1846-1920); Russia, St. Petersburg; late 19th-early 20th century; A la Vieille Russie, Inc.
119. Clock; lapis-lazuli, enamel, gold; Carl Fabergé (1846-1920); Russia, St. Petersburg; late 19th-early 20th century; A la Vieille Russie, Inc.
120. Flask; blown and cut glass; Iran; 9th-10th century; Cooper Union Museum
121. Vase; free-blown *Favrile* glass; Louis Comfort Tiffany (1848-1933); United States, New York; about 1890-1900; Cooper Union Museum
122. Scarab; molded *Favrile* glass; Louis Comfort Tiffany (1848-1933); United States, New York; 1880-1890; Cooper Union Museum
123. Weight and fragment of a weight; black glass; Middle East; 7th to 10th century A.D.; The Corning Museum of Glass
124. Pair of earrings; gold, hummingbirds' heads, glass eyes; France, Paris; mid-19th century; Cooper Union Museum
125. Beetles; Jan Kindler
126. Scarf; silk, blue warp, green weft; India; late 19th century; Cooper Union Museum
127. Ceremonial apron; beetle wings, toucan and hummingbird feathers, human hair, monkey, jaguar and peccary teeth, nuts and seeds; eastern Ecuador, Jivaro Indians; 20th century; The American Museum of Natural History
128. Painting, *Homage to the Square from Afar*; oil on composition board; Josef Albers (1888-); United States, Connecticut; 1959; Sidney Janis Gallery
129. Ceremonial comb; wood, parrot and toucan feathers; Brazil, Rio Branco area, Uapixaná tribe; 20th century; The American Museum of Natural History
130. Preserved Quetzal bird; habitat, Mexico and Central America; The American Museum of Natural History
131. Headdress; macaw and toucan feathers, raffia; eastern Ecuador, Jivaro Indians; 20th century; The American Museum of Natural History
132. *Tanka* (Buddhist ceremonial banner); tempera painting on cotton; Tibet; 19th century; The Newark Museum
133. Textile fragment; wool, double-faced warp-patterned weave; Peru, Tiahuanaco; 1000-1300; Cooper Union Museum
134. Textile panel; wool slit tapestry; Peru, Central Coast; about 15th century; Cooper Union Museum
135. Textile braid; embroidered wool; Peru, Southern Coast; Nazca; 5th to 7th centuries A.D.; Mrs. Penelope Strouth
136. Water bottle; Peru, Paracas; 3rd to 2nd century B.C.; The American Museum of Natural History
137. Water jar; Peru; Nazca; 1st to 4th centuries A.D.; The American Museum of Natural History
138. Water jar, stirrup spout; Peru; Nazca; 4th to 5th century A.D.; The American Museum of Natural History
139. Twined cotton fragments, among the oldest known textiles of the New World; Peru, Chicama Valley, Huaca Prieta; 2500-1200 B.C.; The American Museum of Natural History
140. Shawl; wool embroidered, plain and interlocking twill; India, Kashmir; mid-19th century; Cooper Union Museum
141. Shawl; wool, interlocking twill; North India; 18th century; Cooper Union Museum
142. Camel; gold, champlevé enamel, lacquer, diamond chips; India; Mughal period, about 1800; The Metropolitan Museum of Art; gift of the Shaw Foundation, Inc., 1959
143. Miniature painting, *Krishna at the feet of Radha, and Radha's friend pleading to her to receive Krishna*; paint on paper; Rajasthani or Gujerati School; India, Rajput period; about 1630; The Metro-

- politan Museum of Art; Rogers Fund, 1951
144. Miniature painting, *Ragmala, Peacocks Attracted by the sound of music*; Rajasthani School; India, Rajput period; about 1600; The Metropolitan Museum of Art; Rogers Fund, 1918
 145. Painted and lacquered wood box, *Court scenes*; painted metal hinges and lock; India; Mughal period, 18th century; The Metropolitan Museum of Art; Rogers Fund, 1958
 146. Playing card; painted leather; India; about 1840; Jan Kindler
 147. Vase; tin-enameled earthenware; France, Nevers; mid-18th century; Cooper Union Museum
 148. Vase; porcelain, underglaze decoration; China; Ch'ing dynasty, Ch'ien Lung period (1736-1795); Cooper Union Museum
 149. Jug; tin-enamelled earthenware; Germany, Ansbach; mid-18th century; Cooper Union Museum
 150. Bottle; opaque blown glass with applied glass threads; Europe; 18th century; The Corning Museum of Glass
 151. Dish; earthenware; underglaze decoration; Persia; 13th century; The Metropolitan Museum of Art; Gift of Horace Havemeyer, 1945
 152. Vase; free-blown, cased and acid-etched glass; Emile Gallé (1846-1904); France, Nancy; 1885-1900; The Corning Museum of Glass
 153. Vase; free-blown, cased and acid-etched; Emile Gallé (1846-1904); France, Nancy; about 1900; Cooper Union Museum
 154. Bowl; colorless and clouded green glass; carved decoration; François Décorchemont (1880-); France; first half 20th century; The Corning Museum of Glass
 155. Ceramic bowl, *Chün* ware, reduced copper glaze; China; Sung dynasty (960-1260); The Metropolitan Museum of Art; Fletcher Fund, 1925
 156. Bark cloth; mud-dyed; Belgian Congo, Ituri Forest, BaMbuti (Pygmy) aborigi-
 - nals; The American Museum of Natural History
 157. Vase; *Chün* ware, stoneware, reduced copper glaze; China; Yüan dynasty (1260-1368); Mathias Komor
 158. Bowl; *Chün* ware, stoneware, reduced copper glaze; China; Yüan dynasty (1260-1368); The Metropolitan Museum of Art; Fletcher Fund, 1925
 159. Dish; soft paste, mark of painter Jacques Fontaine; France, Vincennes; before 1753; The Antique Porcelain Company, Inc.
 160. Bowl; frit, painted decorations; Egypt; 19th dynasty (1349-1197 B.C.); Cooper Union Museum
 161. Pair of pendant ornaments for the head; gold alloy, turquoise, pearls, amethyst, coral; Tibet, Lhasa; 19th century; The Newark Museum
 162. Pendant; gold, turquoise, tin; Tibet; 18th century; Cooper Union Museum
 163. Vase; *Rakka* ware; black underglaze decoration; Persia (?); 12th-13th century; The Metropolitan Museum of Art; Bequest of Horace Havemeyer, 1956
 164. Vase; stoneware, *Persian blue* glaze, incised decoration; China; Ming dynasty (1368-1644); The Metropolitan Museum of Art; H. O. Havemeyer Collection, bequest of Mrs. H. O. Havemeyer, 1929
 165. Painted miniature, *Sharaf ad Din 'Ali Yazdi, Battle scene*; School of Herat; Persia; Timurid period, late 15th century; The Metropolitan Museum of Art; Rogers Fund, 1943
 166. Tile; earthenware, lustre-painted; Iran, Kashan; 13th century; Cooper Union Museum
 167. Bottle; earthenware, cobalt blue glaze, metallic oxides (lustre); Persia; first half 17th century; The Metropolitan Museum of Art; Rogers Fund, 1903
 168. Rose-water sprinkler; glass; Persia; 17th century; The Metropolitan Museum of Art; Gift of J. Pierpont Morgan, 1917
 169. Ewer; opaque glass, free blown with ap-

- plied decoration; Spain; probably 18th century; The Corning Museum of Glass
170. Carved ostrich egg; oval medallions representing the Four Continents; Germany, Franconia; 17th century; Cooper Union Museum
 171. Bowl; clouded glass; René Lalique (1860-1945); France, Comès-la-Ville; about 1914; Cooper Union Museum
 172. Bowl; *Mishima* ware (inlaid stoneware); Korea; 12th-13th century; Miss Dorothy Mathews
 173. Dance mask; painted wood, raffia, cowrie shells, beads; Africa; 19th century; Mathias Komor
 174. Textile length; cotton-backed silk checked panned velvet; France (?); 19th century; Cooper Union Museum
 175. Five fragments of cups or bowls; *laticinio* glass; Egypt or Italy; 1st century B.C.; The Corning Museum of Glass
 176. Amphora; glazed stoneware; China; T'ang dynasty (618-905); Cooper Union Museum
 177. Scarf; silk, designed by James H. W. Thompson; Thailand; mid-20th century; Miss Ruth Marton
 178. Bark cloth; Belgian Congo, Ituri Forest, BaMbuti (Pygmy) aboriginals; 20th century; Colin Turnbull
 179. Bowl; porcelain, underglaze with enamel overglaze decoration; China; probably 17th century; The Metropolitan Museum of Art; purchase by subscription, 1879
 180. Covered tureen on stand; soft paste; France, Vincennes; about 1750; The Antique Porcelain Company, Inc.
 181. Waterpot (for use with solid ink slab); porcelain, *peach bloom* glaze; China; K'ang-hsi period (1662-1722); The Metropolitan Museum of Art; H. O. Havemeyer Collection, bequest of Mrs. H. O. Havemeyer, 1929
 182. Vase; porcelain; Japan; 19th century; The Metropolitan Museum of Art; Gift of Charles Stewart Smith, 1893
 183. Tea bowl; *raku* ware (low-fired earthenware); Japan; 17th-18th century; The Metropolitan Museum of Art; Rogers Fund, 1917
 184. Vase; porcelain, *flambé* glaze; Adelaide Robineau (1865-1929); United States, Syracuse; early 20th century; Everson Museum of Art
 185. Painting, *Reading Nude*; gouache; Robert Delaunay (1885-1941); France; 1915; Fine Arts Associates
 186. Vase; opaque glass, free-blown, carved; China; Ch'ing dynasty, probably 19th century; The Corning Museum of Glass
 187. Vase; opaque glass, free-blown, carved; China; Ch'ing dynasty, Ch'ien Lung period (1736-1795); The Corning Museum of Glass
 188. Pair of potpourri groups; soft paste; *rose Pompadour* glaze; France, Vincennes; about 1750; The Antique Porcelain Company, Inc.
 189. Vase; *Favrile* glass, free-blown; Louis Comfort Tiffany (1848-1933); about 1900; Cooper Union Museum
 190. Headdress ornament; kingfisher feathers, lacquer; China; about 1900; Cooper Union Museum
 191. Court lady's summer robe; silk gauze; China; early 20th century; The Metropolitan Museum of Art; Rogers Fund, 1930
 192. Fan; ivory, silk, kingfisher feathers; China; mid-19th century; Cooper Union Museum
 193. Hanging bird cage; carved and inlaid; ivory, jade, woods, nickel alloy, with accessories of ceramic, amber, coral, turquoise, amethyst quartz, kingfisher feathers, jade, ivory and enamelled metal; China; Ch'ing dynasty, Ch'ien Lung period (1735-1796); Cooper Union Museum
 194. Painting, *The Twist*; oil on canvas; Hannes Beckmann (1909-); 1960; Hannes Beckmann
 195. Illuminated manuscript, missal, *Nativity*; Franco-Flemish; about 1470; The Art Museum, Princeton University
 196. Illuminated letter B, cut out, *Pentecost*;

- Italy, Lombardy; about 1480; The Art Museum, Princeton University
197. Illuminated manuscript, psalter, *Christ Rising from the Tomb*; Germany, Augsburg (?); about 1250; The Art Museum, Princeton University
198. Gable from a reliquary, *Coronation of the Virgin*; enamel on metal; France, Limoges; 13th century; The Art Museum, Princeton University
- SYSTEMS, TERMINOLOGY AND COLOR MEASUREMENT
199. Book, *Des Couleurs* E. Chevreul; France, Paris; 1864; Dr. Sidney M. Edelstein
200. CIE (Commission Internationale d'Éclairage) color solid; plots position of selected colors in 9 planes on superimposed chromaticity diagram; Union Carbide Plastics Company
201. Ostwald color solid; chips from the Color Harmony Manual arranged in 12 hue leaves with 28 variations for each hue; Container Corporation of America
202. Munsell color tree; ten major hues in a three-dimensional relationship based on hue, value and chroma; Munsell Color Company, Inc.
203. Constant hue chart; blue to yellow; Munsell Color Company, Inc.
204. Hue circuit; ten major hues at maximum chroma; Munsell Color Company, Inc.
205. Natural value scale; nine gradations between white and black; Munsell Color Company, Inc.
206. Chroma scale; seven gradations of chroma for red; Munsell Color Company, Inc.
207. Ostwald hue circuit; hues arranged in complementary relationship; Cooper Union Art School
208. Ostwald color triad; blue to yellow; Cooper Union Art School
209. Color fan; Dorothy Nickerson; fan arrangement of Munsell Color hues; Munsell Color Company, Inc.
210. Chromaticity diagram; National Bureau of Standards
211. ASA (American Standards Association) Safety Color Code with CIE chromaticity diagram; National Bureau of Standards
212. Demonstration of lighting intensity on color; Large Lamp Department, General Electric Company
213. Textile; compound silk; France, Lyons; 1830-1850; Cooper Union Museum
214. Color names in chemistry; correlation on color names based on the ISCC-NBS (Inter-Society Color Council - National Bureau of Standards) Dictionary of Color Names; National Bureau of Standards
215. Painting, *Some Dimensions and Directions of Color*; oil on wood with applied string; Hilaire Hiler (1898-); United States; 1948; Mrs. David Gliberman
216. New color scale for petroleum products; National Bureau of Standards
217. Rapid-scanning spectrophotometer; American Optical Company, Instrument Division
218. Textile weavings based on Munsell Color System; Mrs. Luis F. Vela
219. *Weaver's blanket*, design composition in color and weave; made by Pola Stout for J. P. Stevens Company; Pola Stout
220. Trinket box; arms of the Dand and Basnet families, court scene, trees and birds in solid beadwork; Frances Dand Basnet; England, Coventry; 1630; Cooper Union Museum
221. Armorial hanging with arms of France and Navarre; tapestry; Gobelins; France, Paris; late 17th century; The Metropolitan Museum of Art; gift of Mrs. Lionel F. Straus; 1953; in memory of Lionel F. Straus
- COLOR AND HUMAN RESPONSE
222. Wallpaper, *Les Deux Pigeons*; printed from wood blocks; Jean Baptiste Réveillon; France, Paris; about 1785; Cooper Union Museum
223. Textile pilaster from a series of wall hangings; ribbed silk embroidered in

- silk and metal; made at the Palazzo Albicini; Italy, Forlì; about 1700; French & Company
224. Textile; printed cotton; Christophe Philippe Oberkampf (1738-1815); France, Jouy; late 18th century; Cooper Union Museum
 225. Chair; carved and painted wood; in the style of Michelangelo Pergolesi (active 1774-1801); England; about 1795; Cooper Union Museum
 226. Textile; silk damask; Italy, Venice; early 18th century; Cooper Union Museum
 227. Textile; silk damask; France or Italy; 18th century; Cooper Union Museum
 228. Textile; silk taffeta brocaded; England, Spitalfields; 1st half 18th century; Cooper Union Museum
 229. Wallpaper pilaster and cornice, *Jardin d'Hiver*; printed from woodblocks; Charles L. L. Muller; manufactured by Jules Defossé; France, Paris; 1851-1855; Cooper Union Museum
 230. Length of carpeting; wool, jute; United States, Ohio; before 1860; Cooper Union Museum
 231. Vase; glass overlaid and cameo-cut; Thomas Faraday (1854-1942); manufactured by Thomas Webb & Sons; England, Stourbridge; about 1890; Cooper Union Museum
 232. Pendant; gold, garnet, enamel, rose diamonds, pearls; United States; mid-19th century; Cooper Union Museum
 233. *Design for the North Wall of the Music Room of the Royal Pavilion at Brighton*; water color on paper; Frederick Crace (1779 - 1859); England; 1818 - 1819; Cooper Union Museum
 234. Textile, *Venice*; compound silk satin; Robert Bonfils; manufactured by Bianchini Férier; France, Paris or Lyons; 1925; Cooper Union Museum
 235. Book, *Les Choses de Paul Poiret*; Georges Lepape; printed by Maquet; France, Paris; 1911; Cooper Union Library
 236. Textile; silk and metal cut and uncut velvet; H. A. Elsberg; France, Lyons; 1910-1915; Cooper Union Museum
 237. Book, *Robes et Femmes*; Enrico Sacchetti; printed by Dorbon-Ainé; France, Paris; 1913; Cooper Union Library
 238. Book, *Decoration in Color*; printed by J. Hoffmann; Germany, Stuttgart; 1927; Cooper Union Library
 239. Wallpaper; printed from woodblocks; René Crevel; France; 1920; Cooper Union Museum
 240. Wallpaper; printed from woodblocks; René Crevel; France; 1920; Cooper Union Museum
 241. Wallpaper; printed from woodblocks; René Crevel; France; 1920; Cooper Union Museum
 242. Bowl; reduction glaze; Gertrud and Otto Natzler; United States, California; about 1950; Everson Museum of Art
 243. Chair; transparent lacquer on wood, cotton slip seat; John Van Koert; manufactured by Heywood-Wakefield Company; United States; 1959; Heywood-Wakefield Company
 244. Vinyl tiles; *Amtico*; American Biltrite Rubber Company
 245. Textile, *Campo Lindo*; printed linen; United States; 1959; Jack Lenor Larsen, Inc.
 246. Textile; printed linen; Sven Markelius; United States; about 1955; Knoll Associates
 247. Textile; printed linen; Ross Lytell; United States; about 1955; Knoll Associates
 248. Painting, *Joseph's Coat*; oil on canvas; Ben Cunningham (1904-); United States; 1949; Ben Cunningham
 249. Theatre costume from *The King and I*; Irene Sharaff; made by the Brooks Costume Company; United States; 1951; Rodgers and Hammerstein
 250. Textile; brocaded piña fiber gauze; Philippine Islands; about 1930; Cooper Union Museum
 251. Textile; checked piña fiber gauze; Philippine Islands; 19th century; Cooper Union Museum
 252. Tablecloth; embroidered sheer cotton;

- Ceylon; early 20th century; Cooper Union Museum
253. Scarf; silk *ikat* (tied and dyed warp threads) in diamond pattern; Thailand; 20th century; Cooper Union Museum
 254. Scarf; silk square; James H. W. Thompson; Thailand; mid-20th century; Miss Ruth Marton
 255. Textile, *Midsummer*; printed linen; Don Wight; United States; about 1954; Jack Lenor Larsen, Inc.
 256. Textile, *Obelisk*; printed linen; Jack Lenor Larsen; United States; about 1958; Jack Lenor Larsen, Inc.
 257. Textile; hand-loomed silk; Thailand; mid-20th century; Thaibok, Inc.
 258. Textile; hand-loomed silk; Thailand; mid-20th century; Thaibok, Inc.
 259. Textile; hand-loomed silk; Thailand; mid-20th century; Thaibok, Inc.
 260. Wallpaper, *Baroque Stripe*; Jack Lenor Larsen; United States; 1960; Karl Mann Associates
 261. Wallpaper, *Citadel*; Jack Lenor Larsen; United States; 1960; Karl Mann Associates
 262. Chalice, Ronald Pearson (1925-); silver, parcel-gilt, cast cup pierced with plique-à-jour enamel; United States, Rochester; 1959; Museum of Contemporary Crafts
 263. Playing cards; France; 18th century; Jan Kindler
 264. Playing cards, *Steamboat Deck*; United States; about 1860; Jan Kindler
 265. Playing cards; A. M. Cassandre; France, Paris; 1947; Jan Kindler
 266. *Kian*, embroidered textile; hemp on ramie, metal; Sumatra; late 19th century; Cooper Union Museum
 267. Red head and black leg; glass inlays; Egypt; late Ptolemaic period (323-30 B.C.); The Corning Museum of Glass
 268. Wedding shoes; leather, wool and metal; India, Rajasthan, Udaipur; mid-20th century; Oppi Untracht
 269. Chasuble, worn during periods of plague; cotton, resist-printed, linen, gold strips; Spain; 18th century; Cooper Union Museum
 270. Bracelet; coral, gold and turquoise; Italy; about 1870; Cooper Union Museum
 271. Bracelet; coral and gold; Italy; about 1850; Cooper Union Museum
 272. Head ornament; silver and imitation coral; Tibet; probably 20th century; The Newark Museum
 273. Scarf for the dead, design of *The Name of God*; cotton, printed; India; 20th century; Oppi Untracht
 274. Buoy globes; Corning Glass Center
 275. Airplane and airport lights; Corning Glass Center
 276. Railroad signal light lenses; Corning Glass Center
 277. Traffic signal roundels; Corning Glass Center
 278. Demonstration of lighting's effect on color; Large Lamp Department, General Electric Company
 279. Bookpaper, *Fantasy*; Ingeborg Börjeson; Sweden; about 1950; Cooper Union Museum
 280. Study of Color and Communications; a research project exploring the effect of colors in reactions to various forms of communications; Social Research, Inc.
 281. Textbooks; development in use of color; Sun Chemical Corporation
 282. Packaging color trials for White Rose Tea; Lippincott and Margulies, Inc.
 283. Cocktail dress, *Sun Goddess*; Le Gip; silk; United States, New York; 1960; Le Gip Studios
 284. Automobile colors; sample colors popular from 1950 to 1960; Allied Chemical Corporation, National Aniline Division, Harmon Colors
 285. Fashion Colors; chart of colors popular from 1950 to 1960; American Fabrics
 286. Home Fashion Colors; chart of colors popular from 1950 to 1960; adapted from graph prepared by Faber Birren for House and Garden
 287. Fall Colors; 1960; Esquire
 288. Standard Color Card — 9th edition; The

- Color Association of the U. S., Inc.
289. Color card, projected colors for Spring, 1960; The Color Association of the U. S., Inc.
 290. Assembly of swatches for development of projected colors for Spring, 1960; The Color Association of the U. S., Inc.
 291. Children's clothing for Spring, 1960; W. T. Grant Company
 292. Assembly of swatches for development of colors for Spring, 1960; W. T. Grant Company
 293. Model for opera setting, *Ariadne auf Naxos*; Robert O'Hearn; United States, New York; 1959; Robert O'Hearn
 294. Theatre costume for *Lute Song*, the Princess before marriage; Robert Edmond Jones (1887-1954); made by Brooks Costume Company; United States, New York; 1945; Brooks Costume Company
 295. Theatre costume for *Lute Song*, the Princess as a bride; Robert Edmond Jones (1887-1954); made by Brooks Costume Company; United States, New York; 1945; Brooks Costume Company
 296. Two sheets of a circus billboard poster; color lithograph; United States; 1950-1958; Cooper Union Museum
 297. Color structure; painted wood; Thornton Rockwell; 1959; Cooper Union Art School
 298. Medieval torture pattern; originally reproduced by Norman E. Hallendy for exhibition, *Look This Way*, organized by the National Industrial Design Council, Ottawa, Canada; NIDC and Norman E. Hallendy
 299. Wood block print, *Three Ladies Strolling*; Japan; 18th-19th century; Cooper Union Museum
 300. Painting, *Peacock*; Japan; 18th-19th century; Cooper Union Museum

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